REPORT ON THE PADUCAH GASEOUS DIFFUSION PLANT

"WORK FOR OTHERS" PROGRAM

INCLUDING

WEAPONS SUPPORT AND DISPOSITION

Department of Energy
Oak Ridge
Operations

COVER PICTURE:

Paducah Gaseous Diffusion Plant Site
Viewing from North to the South
Center: Building C-746-A/B

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EXECUTIVE SUMMARY

Background/Scope

This report discusses the results of a limited review by the Department of Energy–Oak Ridge Operations (DOE–ORO) of the "Work For Others" (WFO) Program including weapons support and disposition at the Paducah Gaseous Diffusion Plant (Paducah) in Paducah, Kentucky, during the period from the 1950s through the 1980s. The purpose of this review was to determine whether processing of materials for these programs may have had an impact on worker health and safety and the environment, which in turn would warrant further evaluation.

A major weapons dismantlement and disposition effort took place in the late 1950s at the Modification Centers in Clarksville, Tennessee (Clarksville), and near Medina, Texas (Medina), as well as at the Pantex Plant (Pantex) near Amarillo, Texas, with some of the weapons components being shipped to Paducah (Ref. 1). This review was initiated due to the discovery of classified information pertaining to weapons support activities at the Paducah site and the discovery of trace-elements not normally associated with gaseous diffusion plant operations such as beryllium, tritium, and cobalt-60. The review was coordinated with the Department of Justice inquiries into weapons work at Paducah.

Based on information received during interviews of former Paducah managers, supervisors, and workers, interviewees consistently indicated that work on nuclear and conventional weapons components was performed at Paducah beginning in the late 1950s. Documentation shows that a formalized WFO program was established in the early 1960s. The intent of the WFO program was to ensure the availability of a stable, skilled Paducah workforce whose machining, manufacturing, and smelting expertise was anticipated to be required as the commercial nuclear industry developed. The program was successful in securing a wide variety of work from other government agencies such as the recovery of precious metals from damaged and retired weapons components, fabrication of Lunar Lander parts for the National Aeronautics and Space Administration, fabrication of large reactor internals for the Oak Ridge National Laboratory, assembly of intricate electronics telemetry packages, fabrication of parts for re-entry vehicles, and manufacture of Joint Test Assembly components for military applications. A major portion of the weapons support activities dealt with the recovery and recycling of metal contained in weapons casings and electronics, as well as the sanitization and demilitarization[1] of weapons parts. The explosive and nuclear physics packages of each weapon were removed prior to shipment to Paducah. The weapons support and disposition effort was terminated in October 1985 by the Manager of the Oak Ridge Operations (Ref. 2).

Results

[1]Sanitization is the removal of classified information from weapons parts; demilitarization is the removal of their military function.

Interviews were held with personnel from Paducah, DOE–ORO, and Pantex. These interviews were held with contractor managers, supervisors, and plant workers who were involved with the WFO program's daily activities to determine the conduct of operations, the types of records kept, and the disposition of records. In addition, interviews were held with DOE managers to determine the program direction provided to the operating contractor. A limited review of records was conducted at Paducah, DOE–ORO, and Pantex to confirm statements made in interviews as well as to establish a technical basis to ascertain if other health issues may have occurred. The information obtained from the interviews and records review, though not a fully documented history, was sufficient to develop an overview of the program activities and to identify five materials (beryllium, cobalt, lead, tritium, and tantalum) associated with WFO as having the potential for adverse health effects and/or potential hazards impact on the environment. Conclusions could not be drawn about other materials encountered, such as strontium-90, cadmium, and manganese-54.

A smelter facility that contained two sweat furnaces was among the facilities at Paducah used for WFO activities. An induction furnace was added in 1976 for the processing of metals with higher melting points. The smelter facility at Paducah was used to destroy the classified aspect of cascade components and recover nickel from components removed from the Paducah, Portsmouth, and Oak Ridge Gaseous Diffusion Plants during continuing cascade improvement programs. Between cascade improvement programs, the smelter was used for the recovery and recycling of metals for the WFO program. DOE and the operating contractors considered the smelter an uncontaminated area with standard industrial hazards. However, as late as 1986, the Paducah Staff found that some radioactive materials were shipped under the WFO program for processing in the smelter. Radioactively contaminated materials from the gaseous diffusion plant were also processed with the same equipment.

Many of the materials formerly handled by the Paducah workforce are known today to be hazardous and require protective measures. In the early days of Paducah operations, the potential hazards were not as well known. At the start of smelter operations, respiratory protective equipment was not generally used to protect workers from airborne vapors or particulates during furnace operation and cleaning of the slag. However, as the operations matured and the potential hazards became better understood, health and safety controls were specified.

A large quantity of lead was processed in the Paducah C-746-A smelter facility. Following the termination of the smelter operations, recovered smelter production logbooks indicate 258,990 pounds of shredded lead was processed. Additionally, lead was scavenged from abandoned Kentucky Ordnance Works (KOW) facilities[2] by using torches to cut and extract the lead. The torching of lead from both KOW facilities and weapons is an area of concern potentially warranting further evaluation. Some WFO work required the smelting and casting of large lead pieces. In the mid-60s through late-70s, Paducah was requested to fabricate x-ray lead shield doors that were poured in two sections with each containing 26,000 pounds of lead. Also, a summary

[2]Paducah was built on the former KOW site.

report of the metals recovered from 14,971,466 pounds of scrap received from Pantex as of December 31, 1985, revealed that more than seven million pounds of aluminum, more than one million pounds of lead, and thousands of pounds of gold and silver had been reclaimed (Ref. 2).

The C-720 Machine Shop provided state-of-the-art capabilities for this era. Much of the WFO work was performed in this facility. The identified work of concern in this facility is the melting and machining of lead and the machining of beryllium, and beryllium-copper compounds. The hazards associated with beryllium were recognized to some extent, but the records and recollection of plant personnel do not show clear evidence that the recommended protective measures, such as controlled ventilation or respirators, were used.

The information gathered on weapons components indicates that there was an understanding between Paducah and Pantex, a major source of weapons components, that no radioactive nuclear materials would be included in the shipments to Paducah (Ref. 3). However, documentation confirms that neutron generators containing radioactive tritium were shipped and buried at Paducah in the 1960s (Ref. nos. 4, 5). In 1981 and 1982, additional documented instances were identified that establish that radioactively contaminated weapons components and waste material were received (Ref. nos. 6, 7). There is a good possibility that some of the contaminated material came from Sandia (Ref. nos. 8, 9). Mid-1982 correspondence discusses the type of radioactively contaminated weapons components and waste material received as well as the return of these materials to Pantex (Ref. nos. 10, 11, 12). After 1982, radiological surveys were performed by Paducah on incoming shipments and contaminated materials were returned to Pantex or buried in the classified burial yard at Paducah. An August 2000 Pantex summary document indicates that health physics characterization data for tritium presents a very low level health hazard to the workers and to the environment for the components shipped from Pantex.

Conclusions

This review has identified five materials to date associated with WFO as having the potential for adverse health effects and/or environmental impacts. These materials were encountered primarily in the processing of weapons-related components. The materials are: beryllium, cobalt, lead, tantalum, and tritium. Based on the records reviewed and the activities described during personnel interviews, there is reasonable assurance that the primary material hazards to which workers may have been exposed have been identified. However, at the time of this report, this evaluation has not been expanded to include known WFO activities in support of the military installations; US Arms Control and Disarmament Operations at Paducah; Modification Centers in Clarksville, Tennessee, and Medina, Texas; Central Intelligence Agency; and other facilities.

The findings presented in this report provide a basis for determining whether the impact of the WFO program at Paducah, including weapons support and disposition, is sufficient to warrant further investigation or additional steps by the Department of Energy related to worker health and safety and the environment. It is recommended that the Office of Environment, Safety and Health assess this information

and determine if additional actions are required.

Recommendations

Based on the information obtained during this review, the following recommendations are made:

1) The torching, machining, and melting of lead and the machining and crushing of beryllium and beryllium-copper alloy should be evaluated further.

2) In light of information regarding the burial of neutron generators, beryllium contaminated materials, and the volume of beryllium and other materials from the weapons program, a further review of the burial practices should be performed in order to gain confidence in the long-term stability of the burial containers and the materials buried with special attention prior to excavation.

3) The records from the WFO program should be gathered in a central location, indexed, and cross-checked with Pantex and other facility records to validate and quantify the hazards identified.

4) The information in this report should be provided to the various stakeholders at the site, state and federal regulatory agencies, and the public to apprise them of the past activities that took place at the site.

1.0 INTRODUCTION

1.1 Purpose and Scope of the Review

The Department of Energy-Oak Ridge Operations (ORO) has initiated a review of the "Work For Others" (WFO) program including the weapons support and disposition activities at the Paducah Gaseous Diffusion Plant (Paducah). The purpose of this review was to determine to what degree these programs involved hazards that may have had an impact on worker health and safety and the environment. The results of this initial review were expected to provide input for determining whether further investigation is warranted of on-site environmental conditions and the health impact on personnel who operated the various facilities at the plant over its life. This review was initiated in response to the discovery of unmarked photographs and negatives while following up the allegations of weapons work at the Paducah site. The photographs and negatives were subsequently reviewed and determined to contain "Secret-Restricted Data." They were marked appropriately and placed in secure storage.

In addition to weapons support and disposition efforts, other activities were conducted at Paducah under the WFO program. WFO activities were performed for a multitude of government agencies over several decades. This review of the WFO program considered the hazards associated with weapons components metal recovery, smelter operation, and machine shop activities. These hazards are of interest with regard to identification of potentially hazardous operations involving substances, such as lead and beryllium.

This review effort sought to compile as much factual information as could be recovered to ascertain process methods and controls, the scope of weapons material recovery effort, the disposition of weapons components, and special machining operations, including fabrication of weapons components.

1.2 Review Methodology

Two significant factors affected the conduct of the review: the activities of interest occurred some time ago and the weapons support and disposition efforts were classified. Consequently, a great deal of information was not readily available. Concerns and allegations, disclosed to both the Department of Energy (DOE) and the Department of Justice (DOJ), about hazardous activities in "secret" or "suspect" rooms could not be evaluated by simply going to those rooms in a particular facility, since those rooms have been cleaned out and reused for other purposes. Building C-710 Laboratory, Building C-720 Machine Shop, and portions of the Building C-400 Decontamination Facility are active facilities today. Buildings associated with the smelter, C-746-A and C-746-B, are now abandoned facilities or warehouses (See: Exhibit 1 - - Buildings C-746-A and C-746-B).

Exhibit 1 - - Buildings C-746-A and C-746-B

1.2.1 Interviews

Information on WFO and weapons support and disposition activities that occurred over a period of time as far back as 50 years ago were not readily available or, in some cases, not at all. Therefore, the initial sources of information for this review were interviews of current and former Paducah personnel involved with WFO activities either directly or indirectly. It was anticipated that interviewees would be able to provide information relative to materials received, the precautions taken when performing the various work activities, the processes used in dismantling and recovering metals from the weapons components, and the disposition of other waste/scrap material. In the case of the overall WFO program activities, interviewers sought to learn what was manufactured, for whom, and whether there were any hazardous materials involved in the operations. Using corporate knowledge and lists of former employees, including volunteers from public meetings, an interview list of potential DOE and Contractor interview candidates at Paducah and Oak Ridge was developed. After screening the list of candidates, the final interview list contained a cross-section of Paducah personnel from management, supervision, and the work force to provide a broader perspective of the operations.

Over the course of several months, more than 50 interviews of personnel were conducted in Paducah, Kentucky; Oak Ridge, Tennessee; and at the Pantex Plant (Pantex) near Amarillo, Texas. Some interviews led to documentation that confirmed the statements made during the interviews and others identified potential areas for further inquiry. The information obtained from interviews was used to identify the documentation that should be sought to confirm the accuracy of interviewees' recollection.

1.2.2 Record Reviews

A review of Paducah records was conducted to collect relevant documentation located in plant files. Included in these records were both classified and unclassified photographs of Paducah

facilities, operations, and products. Additional searches of the plant databases and document storage areas were conducted to look for WFO-relevant information on subjects such as the classified burial yard. The personnel interviews were helpful in locating records that were boxed up and put aside for storage. Classified and unclassified records were reviewed at the ORO Office, of which Paducah is a part; at the Paducah Gaseous Diffusion Plant where the work took place; and at the Pantex Plant, a major source of the weapon components shipped to Paducah. Document reviews were not intended to retrieve every detail that may have been recorded, but to recover sufficient information to get an understanding of what occurred and what precautions and protections were used. This was also due, in part, because some records were no longer available and the available operational records were not of sufficient detail to understand how the work was performed. The general categories of Paducah records retrieved are listed below; the records in a particular category are not necessarily complete.

- Equipment and plant drawings of the smelter facility
- Records of materials received at Paducah for machining and smelting
- Records of metals recovered from smelting operations
- Reports of metals analysis
- Weapons component disassembly and repair operations records
- Smelter operational logs and daily checks
- Smelter operational instructions and procedures
- Machining operations records
- Records of shipments from Paducah
- Documentation of environmental safety and health practices including hazardous work permits
- Event and accident reports
- Work personnel records
- Security plans and records
- Maintenance records and work orders
- Project management documents and accounting records
- Waste handling instructions

Some operational records were found stored in drums in the C-746-B facility (See: Exhibit 2 - - Building C-746-B). These records were surveyed for radiological contamination and placed in interim storage in the C-200 basement. Only a limited review has been made by DOE as of this report. Additional records, some of which have been indexed, are located in the C-710 records vault. Other related records, such as procurement and accounting records, are in the Building C-100 vault, and some Paducah-related records are also stored in the Oak Ridge Y-12, Building 9711-5, records storage vault. In late June through August 2000, additional large quantities of documents were recovered at Paducah, which may provide historical information

Exhibit 2 - - Building C-746-B

related to this review. Resource limitations and the difficulty in the accessibility of these documents has inhibited a review effort for determining their applicability to this report.

1.2.3 Review and Coordination with the Department of Justice

As this review began in the Fall of 1999, DOJ on behalf of the Government was also investigating activities at Paducah in regard to a lawsuit filed by an environmental group and Paducah workers. This suit alleges fraud on the part of operating contractors at Paducah based on current and past environment, safety and health violations. One of the activities that DOJ investigated was the WFO program. An informal agreement was put into effect between DOE and DOJ regarding the coordination of employee interviews and the conduct of document searches and reviews at Paducah, DOE-ORO, and Pantex.

1.2.4 Handling of Classified Information

Much of the detailed information concerning the weapons support and disposition activities at Paducah is still classified. The review of classified records and personnel interviews required establishing secure areas for storage of classified records and holding classified discussions. The review of this program involved the preparation and issuance of an "Authorization for Disclosure" for formerly Q-cleared interviewees and development of a security plan for the review and storage of classified material.

1.3 Information on Paducah Gaseous Diffusion Plant Background

The Paducah plant is located in McCracken Country, Kentucky, approximately 10 miles west of the city of Paducah and 3 miles south of the Ohio River. The site occupies about 3,425 acres of which 750 acres are within a security fence and contain uranium enrichment process equipment and support facilities. The mission of Paducah is to "enrich" uranium for use in domestic and foreign commercial power reactors.

Production of enriched uranium began in the early 1940s as a United States defense initiative to produce fissionable material for atomic weapons. All of the enrichment facilities were initially included in this defense initiative. Later, the nuclear weapons program, including the enrichment facilities, were transferred to the Atomic Energy Commission (AEC). On December 15, 1950, the National Security Resources Board
chose the Paducah site for the second gaseous diffusion plant. The first gaseous diffusion plant (K-25) was at Oak Ridge, Tennessee. The second site chosen was the old Kentucky Ordnance Works (KOW). The KOW was a production facility for gunpowder and TNT for World War II and resided on more than 5,000 acres. The above-ground structures at KOW were dismantled and a new government facility was started almost simultaneously. Early construction utilized some of the KOW infrastructure for both construction and initial operation of the Paducah plant. During the early years (1950s and 1960s) the plant was secured and protected the same as other

facilities involved in the Cold War effort. Over the period of time from 1952 until the late 1980s, several different programs were conducted at the Paducah plant that were separate from the primary uranium enrichment mission. Paducah was considered the prime facility for metals recycling and recovery by the AEC (Ref. 5).

The Energy Policy Act of 1992 created the United States Enrichment Corporation (USEC) and was the first step in the process of privatizing the government's uranium enrichment enterprises. The Nuclear Regulatory Commission (NRC) granted a certificate of compliance to the USEC, as operator of the leased portion of the plant in November 1996, under 10 CFR Part 76, and regulatory oversight of enrichment operations was transferred from DOE to the NRC in March 1997.

DOE retains responsibility for the environmental restoration program, most elements of the waste management program, and all waste materials generated by past DOE (and predecessor) activities. In general, DOE is responsible for legacy issues.

2.0 OVERVIEW OF THE "WORK FOR OTHERS" PROGRAMS

During the era from World War II until the mid-1950s, three uranium enrichment production facilities were built in the eastern United States. These facilities, located near Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio, were designed to support the nation's nuclear defense needs by supplying enriched uranium. By the early 1960s, defense needs were nearing fulfillment. Closing one or more of the enrichment plants was discussed. At this point in time, the commercial nuclear power industry was in its infancy and had not developed a need for the low enrichment capability of these plants. Concerned about the prospects that the Paducah Plant would be forced to deeply reduce the
labor force and aware of the need to keep skilled craftsmen for planned major plant improvements, plant management of the era initiated a search for work that might be done at the Paducah Plant from inside and outside of the defense complex.

2.1 "WORK FOR OTHERS" Program

The WFO Program began in the early 1960s, when the contractor management at Paducah contacted and visited major defense contractors to obtain work requiring state-of-the-art or heavy industrial machining. A very diversified range of work orders were obtained from organizations such as the National Laboratories (Lawrence Livermore, Oak Ridge, Sandia, Argonne, etc.), several Department of Defense research centers, and the National Aeronautics and Space Administration (NASA). The work performed ranged from the machining of re-entry nose cones for missiles to the complete fabrication of telemetry electronics and trailers for Sandia National Labs. A "white" room was established in the C-720 facility for the purpose of manufacturing a portion of the Lunar Lander for NASA and other contaminant sensitive equipment.

Based on the interviews with several contractor managers, the WFO Program continued until 1988 with varying degrees of emphasis as the level of work on the gaseous diffusion process varied. Due to the classified nature of some activities, not all of the machining and manufacturing operations conducted during this period are widely known. A booklet, "Paducah Plant Capabilities," was prepared and issued in September 1963 (Ref. 13). During the mid-80s, a revised edition (Ref. 14), "Production Facilities Capabilities; Oak Ridge, Tennessee; Paducah, Kentucky," discusses a wide variety of manufacturing capabilities and cites many examples of heavy duty machining, intricate machining, and complex electronic manufacturing. The booklet points out that the Paducah and Oak
Ridge Gaseous Diffusion Plants had the capability to work with beryllium-copper alloy. Table 1 provides a listing of the agencies that this review determined had contracted with Paducah for manufacturing services.

Table 1. Examples of Facilities and Agencies that the Paducah Plant Provided with Manufacturing Services

Oak Ridge Gaseous Diffusion Plant (K-25)	Savannah River Site	Sandia National Laboratory
Portsmouth Gaseous Diffusion Plant	Argonne National Laboratory	Ames Research Center
Pantex Plant	Lawrence Livermore National Laboratory	Department of Defense (Air Force, Army, Navy)
Y-12 Plant	Oak Ridge National Laboratory	NASA

2.2 Weapons Components/ Metal Recovery Program

After the decision to search for fabrication work outside the enrichment complex, Paducah's contractor management contacted the Department of Defense and the Atomic Energy Commission. An agreement was established to dismantle damaged or retired nuclear weapons components to sanitize/demilitarize the classified shapes and recover valuable metals and materials. At the time, the entire plant was a classified facility and a "Q" clearance was required by workers. In conjunction with the weapons dismantlement activity during the 1960s, the Atomic Energy Commission designated Paducah as "The Center for Recovery of Precious and Valuable Metals." This work was not a part of the Paducah's primary mission, and its performance was not widely known even among plant personnel who worked there when the work was ongoing.

Beginning in the 1960s, weapon components were shipped from Pantex, where the explosives and nuclear physics packages were removed. These weapons components

were shipped by truck and received at the north side of the smelter, Building C-746-A. Interviewees stated that they routinely pushed the weapons casings off the truck or dropped them from forklifts onto the concrete floor so that the impact would break open the casings. If this failed to break apart the casing, operators sometimes rammed the casing into one of the steel columns supporting the building. Bent columns could be seen in the facility. Casings were also taken to C-720 where a 100-ton press was used to crack them open.

After opening the weapon casing, personnel sorted through the parts, and separated the components containing gold. Other metals were collected in piles of similar metals. Those parts that could not be recovered were generally smashed or broken up to destroy the shape and placed in a container earmarked for disposal in the classified burial yard (Ref. 15). Parts that consisted of material that could be destroyed by melting were sent through the smelting operation rather than mechanically altering their shape.

In addition to weapons components shipped from Pantex, there is evidence that weapons components were shipped directly from other sources such as military bases. While detailed verification has not yet been found, knowledgeable interviewees suggest that weapons components originating from military sources could have been training assemblies used in exercises. These assemblies looked and weighed the same as a "full-up" weapon system, but did not contain either the explosives or nuclear physics packages.

Paducah also received tantalum-182 which was detected during building surveys by health physics technicians. The irradiated tantalum was the tantalum-182 isotope, which has a half-life of 115 days. The amount of material received and the date of receipt is unknown as of this writing. It is estimated to have occurred in the late 1950s/ early 1960s time frame.

Paducah was the headquarters for a "Cloud Gap" field exercise in 1967. The "Cloud Gap" program supported the 1965 Disarmament Agreements of an Eighteen-Nation Disarmament Committee in Geneva, Switzerland. The "Cloud Gap" Organization and program was jointly staffed and financed by the US Arms Control and Disarmament Agency and the Department of Defense (Ref. 16). Several activities were sponsored by the "Cloud Gap" organization. In 1967, one of these activities (for which Paducah was the Headquarters) was announced and was designated as "CG-34." CG-34 was a field exercise to evaluate methods and procedures contemplated for demonstrating the destruction of nuclear weapons without revealing classified weapon design information (Ref. nos. 17, 18). It was also intended to demonstrate that the full measure of fissionable materials had been released for peaceful purposes and submitted to international safeguards. The prime reason for choosing Paducah as headquarters for the CG-34 operation was that Paducah was already involved in an ongoing weapons destruction program. The exercise also involved other facilities in Kentucky, Tennessee, Colorado, and Texas.

Weapon components dismantlement and metal recovery efforts were discontinued in October 1985 at the direction of the Manager DOE Oak Ridge Operations (ORO).
Limited numbers of weapons components were shipped to Paducah following the directive to discontinue weapons activities. The weapons components inventory continued to be processed in the smelter until the backlog was eliminated on October 25, 1985 (Ref. 2).
In September 1986, the C-746-A facility was placed in "Standby."

According to historical records and interviews, gold was one of the most desired metals recovered in the metal recycling operation. The proceeds from its sale reduced the overhead costs of the operation and, on occasion, resulted in surplus funds reimbursed to Pantex. Gold was obtained primarily from electronic circuit board contacts. Recovery of the gold from electronic parts was performed in the C-400 Decontamination facility. Electronics parts were taken from the smelter facility to the C-400 facility where the
circuit boards and other parts were dissolved in an acid vat overnight, leaving the undissolved gold for collection. In addition to gold, substantial metal recovery operations were conducted for aluminum, lead, nickel, and silver.

2.2.1 Pantex Weapons Components Activities

In a coordinated DOE, DOJ, and Department of Defense effort, Pantex records and information sources were evaluated for shipment of potential hazardous materials that
were being identified at Paducah. The Manager of DOE Albuquerque Operations Office (DOE-AL) provided the coordination and support to allow records managers and line managers to research archived records and current files for documentation supporting the evaluation of weapons components being shipped to Paducah. A Pantex Security Plan
was issued, and those persons who were involved in disposition of weapons components
at Pantex were made available for individual interviews.

Through documentation review and interviews, it was established that Pantex shipped weapons components without the explosive and nuclear physics packages to Paducah and to other government facilities for material reclamation or burial. The DOE-AL accountability program rules out transfer of Special Nuclear Material to Paducah. Due to the length of time that has passed since these dismantlement activities were performed, as well as the changes within the retention and control of supporting records and documentation processes, an exact quantity of individual components or parts from each disassembled weapon could not be established. However, it is possible to establish what weapon parts or components were sent to Paducah with some assurance. Pantex Health Physics personnel indicated that it is possible to provide weapon material characterization data estimates of 1) the hazards for the workers handling the subject parts, and 2) the consequences to the environment for the burial of these items.

2.3 Current Status of Weapons Support and Disposition and WFO Activities

The smelter facility still exists, although it is in a state of disrepair. Contaminated metal ingots are stored near the facility, including most of the nickel ingots that were made from the recycle of cascade materials during gaseous diffusion plant improvement programs. Empty casings for nuclear weapons components can be seen above ground behind the smelter facility (See: Exhibit 3 - - Building C-746-A (Unclassified)). Active use of the classified burial yard for weapons-related materials was discontinued around February 1986. A small amount of material was buried in the classified burial yard during one month in 1987. There is no indication that the landfill has been disturbed since the closure in 1987.

3.0 SUMMARY OF INFORMATION COLLECTED

In the search for and review of Paducah documents, hundreds of photographs were examined, and thousands of smelter records were recovered, although examination of these records is incomplete. In addition, database searches identified several documents which provide information on the classified burial and other burial yards. Limited historical health physics records in the C-710 vault were also reviewed. A revealing document (Ref. 14) on the WFO program was obtained from the lead manager responsible for marketing Paducah's capability. Several useful document summaries have been obtained from ORO's review of precious metal sales.

The information collected and reviewed for this report to date is sufficient to determine basically what occurred at Paducah from the 1950s through the 1980s in support of WFO and to draw general conclusions regarding some of the hazards present. An estimated time line for the various WFO program activities is provided at the end of this report, Appendix A: Chronology of Paducah Work For Others Activities 1958 - 1988.

3.1 Work for Others Program Activities

3.1.1 Smelter Operations/ Metal Recovery and Fabrication

Smelting operations for the WFO program were carried out from the early 1960s to 1986. The primary metals recovered from the weapon components activities were aluminum, lead, and gold. A general layout of the smelter facility, including the weapons components dismantlement areas, is shown below in Figure 1. The aluminum was smelted in the clean sweat furnace. In the early years of the Paducah operations, there were indications and statements given that lead was cut by torching and removing it from KOW facilities as a source for lead fabrication. Significant lead fabrication work was done as evidenced by discovery of a photograph showing the pouring of melted lead to form a massive shielding door.

Estimates made from the photograph suggest that each of the doors fabricated contained approximately 10 - 20 tons of lead. In a Mason and Hanger Corporation (Burlington) memorandum dated December 9, 1966, Paducah was requested to fabricate

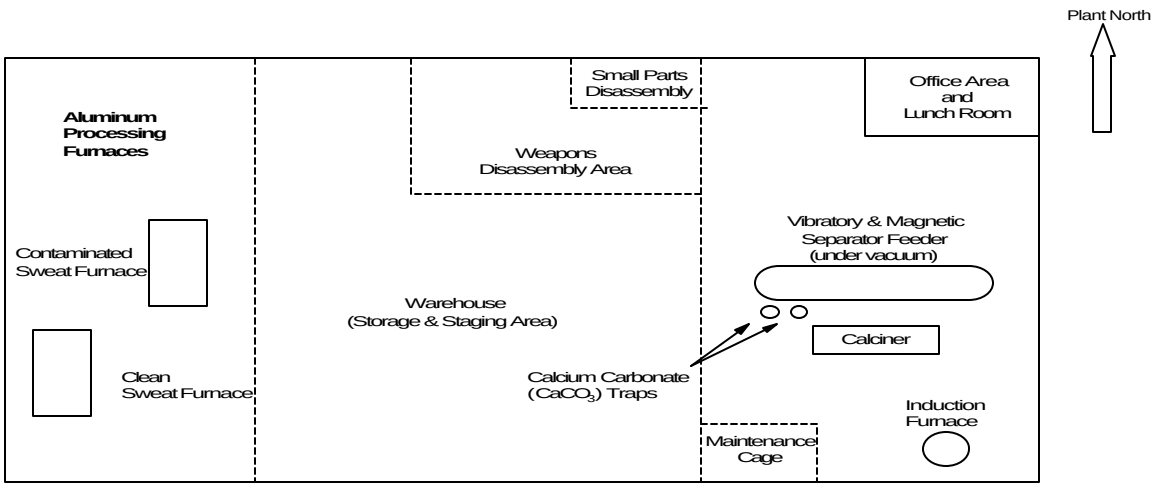


Figure 1. General Arrangement of C-746-A Smelter Facility

x-ray lead shield doors. Additional information indicates that the lead was poured in C-746 and the forms for the doors were milled in C-720. The doors were poured in two sections with each containing 26,000 pounds of lead. Two additional doors were made in 1971 and in the 1978-1979 time frame.

The shredding of lead occurred in 1981–1982 to make additional space available for the melting of clean and contaminated nickel. According to records collected to support a study of metal recovery work, lead was shredded at the smelter facility. Smelter production logbooks indicated 258,990 pounds of shredded lead were processed. In a

C-746-A Status Report (Ref. 2), it states that the Pantex program was initiated in 1965 and concluded in 1986. The report provides a summary of the metals recovered from the 14,971,466 pounds of scrap received from Pantex as of December 31, 1985. More than seven million pounds of aluminum, more than one million pounds of lead, and thousands of pounds of gold and silver were recovered. Also, the report indicated that $ 1,702,000 cash was transferred to Pantex.

Another major source of metals recovery was from the upgrade and improvement of the gaseous diffusion equipment which resulted in a large amount of contaminated and some clean aluminum as well as nickel. The metals originating from the gaseous diffusion plants were known to be contaminated with uranium and traces of transuranic elements such as neptunium, plutonium, and americium (Ref. 19). (Some early measurements of the air-borne dust when the furnaces were in operation with melts of material containing radioactive elements raised the possibility that plant limits for uranium and transuranics could have been exceeded.) Smaller amounts of clean Monel metal and hafnium were also smelted. In 1977, after the melting of radioactively contaminated material from the diffusion plant converters, the urinalysis results of 18 employees showed elevated

concentrations of uranium. Based on these results, respiratory protection was recommended during smelter operation. Documents reviewed called for instructions in the procedures for furnace operators to wear respirators (Ref. nos. 20, 21). This requirement was also mentioned in one of the interviews.

Several individuals who had worked in the smelter facility were interviewed. According to these interviewees, in the early days of the furnace operation, the practice was to perform smelter operations in street clothes. There was no special protection used when removing slag, such as from lead smelting, from the walls of the furnaces. Some time after 1960, employees were issued company clothing, but even this practice was on a facility by facility basis and not a plant-wide requirement. The constant use of a respirator or breathing apparatus could not be confirmed even though the work area temperature could be high during the process of removing slag from inside the furnace. If suspended matter or aerosols were created by the slag removal, workers may have inhaled these particles.

3.1.2 Manufacturing in C-720

The C-720 large machine shop and maintenance facility possessed an impressive array of equipment that allowed experienced personnel in the facilities to do state-of-the-art sophisticated machining of almost any size. From the early 1960s until approximately 1988, this facility produced a varied list of products ranging of Lunar Lander components to major compressor sections for NASA. A full scale Centaur Rocket pad was built as
was a thermal neutron shield for the Oak Ridge National Laboratory Molten Salt Reactor.

Telemetry electronics were built for Sandia as well as a fully outfitted telemetry van for tracking missile launches. Many other devices were built, some of which are listed as examples of Paducah C-720 activity in Table 2. In addition, lead was also melted and machined in C-720 until the early 1980s.

Table 2. Examples of the Manufacturing Capability at Paducah

• Aircraft Engine Parts	• Irradiated Fuel Carrier	• Rocket Fuel Injectors
• Heat Exchangers	• Nose Cones	• Thermal Shield for Molten Salt Reactor
• High Flux Magnet Coils	• Chemical Reaction Chambers	• Wind Tunnels

A booklet (Ref. 13), produced in the mid-1980s following the assumption of the Paducah contract by Martin Marietta, illustrates the many capabilities of the C-720 facility and shows examples of items previously built under contract. One of the capabilities listed in the booklet was the ability to work with beryllium-copper (Be-Cu).

Beryllium (Be) metals and Be-Cu alloys were machined in Building C-720 in 1965. According to internal correspondence (Ref. 22), additional beryllium work was postulated by plant management. This correspondence also indicates that plant management was concerned about the potential hazards of working with both Be metal and Be-Cu alloy. Confirmation of further beryllium work has not been discovered. Literature searches referenced in the correspondence identified the potential hazards and health effects. This correspondence states that "the hazard of machining beryllium-copper is obviously much less than that of machining pure beryllium metal. However, there is still enough hazard involved that local exhaust ventilation should be employed on the operating machine..." (Ref. 22). The use of a coolant was recommended where possible to greatly reduce the amount of Be which could become airborne. A 1980 internal correspondence memorandum (Ref. 23) states that respiratory protection was required when local ventilation was not available. Interviewees talked about the crushing of weapon casings with the machine presses. Some of the weapons casings are known to contain beryllium.

3.2 Relevant Weapons Component Information

Based on the interviews and records reviewed, an implied understanding existed with Pantex (Ref. 3) to ship only non-radioactive parts to Paducah. The explosive and nuclear physics packages for the nuclear and thermonuclear devices were to be removed by Pantex prior to shipment to Paducah. This would allow the workers to dismantle the weapons remains without health physics controls. A significant amount of aluminum, lead, and gold were subsequently recovered.

Once the weapons were opened, gold-bearing components were separated from the other materials. The remaining metals were sorted according to whether they could be melted.

Materials that could not be smelted or were not reusable were smashed to destroy the classified shape and placed in a trash bin for burial in the classified burial yard (Ref. nos. 4, 5). According to interviewees, sometimes the metals being smelted did not behave according to expectation. For example, a lightweight shiny metal was sometimes in the mix that did not melt like aluminum. Also, some metals or compositions were received were unfamiliar to workers.

A large number of weapons components were shipped to Oak Ridge Y-12 Plant for initial dismantlement while Paducah was installing a new induction furnace. The dismantled components were later returned to Paducah for metal recovery and disposal. According to a former smelter supervisor because new furnace effort preoccupied personnel in the smelting operation, two weapons, without the explosives and nuclear physics packages, were buried without disassembly in the classified burial yard. No documentation was found to corroborate this information.

Because of the understanding to ship only non-radioactive parts to Paducah, there were no processes in place to survey materials for radioactive contamination. However, in 1982 the new smelter supervisor asked about the material being received, and a Geiger-Mueller counter was used to survey several boxes received from Pantex. Some boxes were found to contain radioactive material. A more thorough investigation into the shipments and discussions with Pantex ensued. It was determined that, among the shipments of materials received, there were several inadvertent shipments of neutron generators and uranium chips (Ref. 10) among the boxes of material received. According to the correspondence (Ref. nos. 10, 11) between managers at Paducah and letters sent to Pantex, approximately 20 neutron generators in eight boxes, several cone shaped parts, and several other unspecified parts were received that contained radioactive materials, most of which were returned to Pantex. The neutron generators from three of the boxes were buried in the classified burial yard. (A 1990 site survey showed levels of tritium in five of eight effluent outfalls; however, no follow up was done at the time.) The correspondence between Paducah and Pantex also described the estimated dose that would be received from removing certain objects from mid-sections, and then describes a large number of mid-sections in fiber drums.

Contact measurements found dose rates on components such as neutron generators ranged from 30 to 60 mr/hr. In addition, measurements at Paducah identified tritium, cobalt-60, and tantalum-182 contamination as sources of the radiation (Ref. 11). According to Paducah records, Pantex described the radiation as tritium or tantalum contamination depending on the weapon part. The Health Physics Department at Pantex has indicated that the tantalum associated with the Pantex weapons components is tantalum-181 and not radioactive; thereby, it is expected that tantalum-182 must have been shipped from another program. Later surveys of the building showed some residual contamination of tantalum. This further indicated the possibility that tritium, cobalt, and tantalum were all present. In addition, some material described as a black powder was found on a component in the gold processing and was discovered to be radioactive, measuring 90 mr/hr. That material was shipped in error by Pantex. Some of these items were buried at Paducah and some were returned to Pantex. Estimates of the dose to

personnel who dismantled parts from the mid-section of weapons were approximately 100 millirem to the hands. At that time, there was no immediate concern about potential worker exposure (Ref. nos. 10, 11); however, personnel were directed to monitor future shipments for radioactivity. A later report indicates that depleted uranium was returned to Pantex (Ref. 12).

Interviews with workers from this facility, confirmed that radiological controls were not a routine part of the weapons component and metal recovery operations. The smelter facility operated "loosely" within the Paducah organization and some of the dismantlement practices may not have been in full accord with industrial safety practices. However, smelter workers received routine bioassay monitoring and whole body counts were performed.

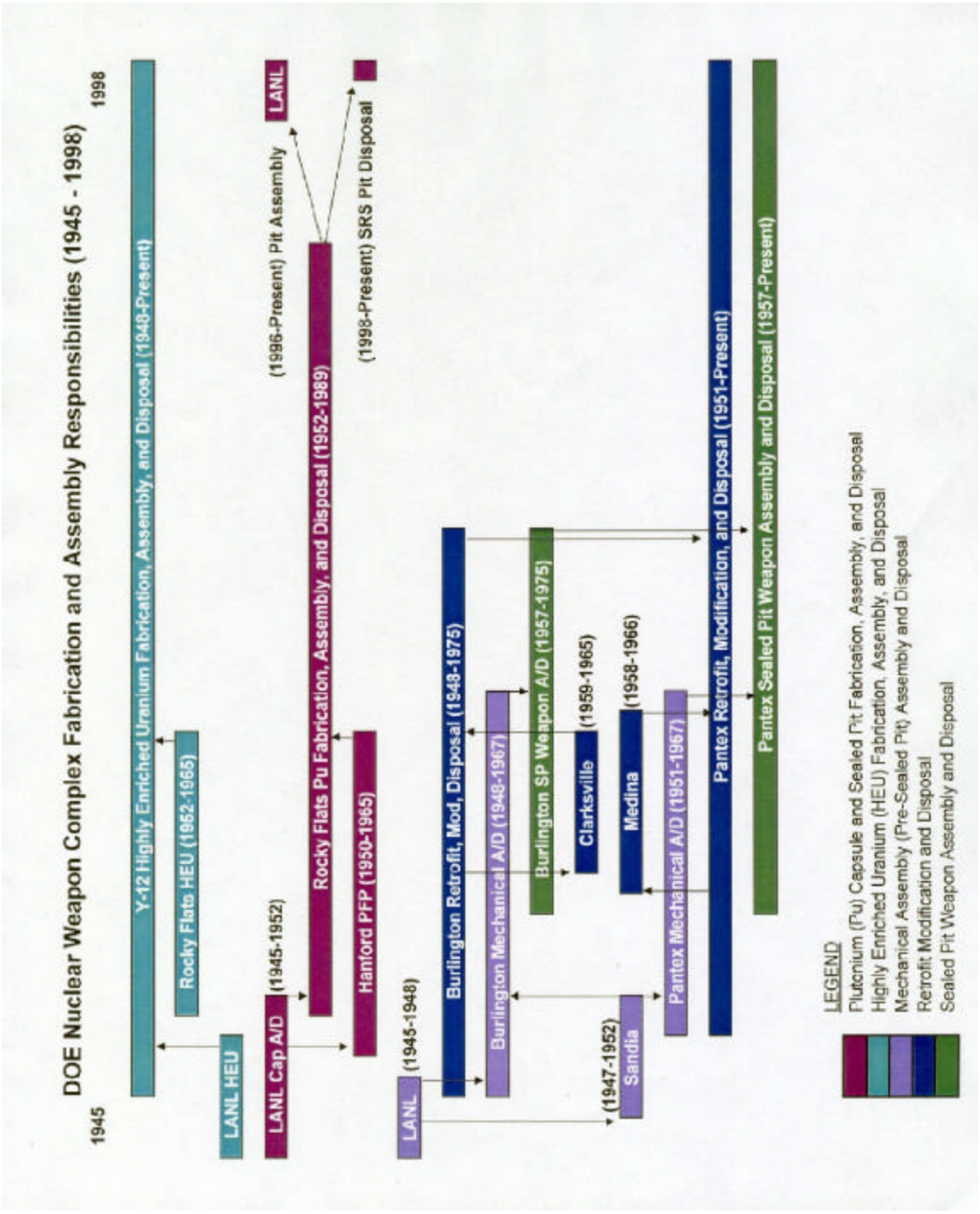
A memo (Ref. 10) from the smelter records indicates that in 1965 neutron generators were shipped to Paducah. The facility log books record that a number of such devices were buried in the classified burial yard. However, at some point in time the policy had changed to not accept such material at Paducah (Ref. 2). This issue of radioactive material receipts may also relate to material from other sources. For example, a 1967 memo concerning material scrap (aluminum, lead, gold-plated scrap and "H-gear" [weapon carts]) sent from Fort Campbell stated that the material has been included with the Mason and Hanger (the operating contractor at Pantex) scrap for processing.

During the past few days prior to finalizing this report, four additional memoranda were located which provide additional information on neutron generators and other radioactive materials received at Paducah (Ref. nos. 6, 7, 8, 9). A 1963 memorandum provides notes regarding a discussion of joint participation on Sandia work with DOE-ORO and Paducah (Ref. 9). July 7, 1982, Notes on C-746-A Weapons Scrap Incident, discusses tantalum-182, gold nose pieces, cobalt-60, depleted uranium, and neutron generator parts from Sandia (Ref. 8). These documents clearly indicate some materials being sent to Paducah from other facilities, aside from Pantex.

There is some indication that other industrial/military facilities may have sent weapons material to Paducah. The following two pages provides a map and chart that identifies some of the Nuclear Weapon Component (NWC) Historical Assembly/Disassembly Locations and a time-line chart indicates DOE Nuclear Weapon Complex Fabrication and Assembly Responsibilities from 1945 - 1998 (Ref. 24).


UNCLASSIFIED
NWC Historical Assembly/Disassembly Locations
BURLINGTON
Y-12
CLARKSVILLE
ROCKY FLATS
NEVADA TEST SITE
LOS ALAMOS
SANDIA TECH AREA II
PANTEX
MEDINA
Nuclear Testing
Nevada Test Site
Major Components
Y-12
RockyFlats
Los Alamos
Assembly Plants
Pantex
Burlington
Clarksville
Medina
Sandia Tech Area II
UNCLASSIFIED

UNCLASSIFIED



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4.0 CONCLUSIONS

A major "Work For Others" program existed at Paducah for over 30 years and involved both nuclear and non-nuclear related work. The WFO program and weapons components work at Paducah were initiated to keep workers employed by doing work for other government financed facilities in order to have trained workers available at a later time when the skill of those workers would be needed at Paducah. The potential hazards associated with handling materials being processed were not fully understood in the early stages of the WFO program.

4.1 C-746 Smelting Operations

Smelter facility operations included metal recovery from several sources and for a variety of programs. Each campaign had potential to expose workers to dust contaminated with the particular metal being smelted.

Also Pantex shipped foam and plastics contaminated with beryllium, tritium, and uranium oxide; however, the existing contamination characterization data from Pantex do not indicate that the subject materials presented any radiation health risks. The foam and plastics were generally piled in a corner until an amount large enough to fill the burial container was collected. Paducah workers were initially not aware of the contamination. In addition, due to the nature of the smelting operation, workers were subject to heat stress and respiratory tract stress from the high ambient air temperatures.

Personnel exposure to hazards associated with lead processes may have occurred mainly during cleaning operations and/or melting for fabrication of lead items. Given the means of cleaning the furnace after use that was described, there was potential for uptake of airborne lead particles and other contaminants when such operations were conducted. A summary report of the metals recovered from Pantex scrap indicates that over seven million pounds of aluminum, over one million pounds of lead, and thousands of pounds gold and silver were recovered.

4.2 C-720 Manufacturing Operations

As discussed in Section 3.1.2 above, the machining operations performed in C-720, exposed workers to typical standard industrial hazards to the extent the parts made and processes performed have been documented. Beryllium metals and beryllium-copper alloy machining and the intake of the particles especially in the oxidized state can have serious worker health consequences. A 1965 letter (Ref. 22) in the WFO records indicates that small machining operations on beryllium had been performed. To date only one person interviewed has indicated that he machined beryllium. Further, beryllium parts were potentially crushed in presses. Current information is too limited to determine whether there is a serious issue associated with this

manufacturing capability though large quantities of beryllium could have been crushed in this manner. While it is evident that workers were involved in the machining of lead and also melted lead in C-720, a search of the C-720 records for work assignments and purchase orders may be necessary to determine how many employees were included in these tasks and what jobs were actually performed. For example, workers were involved in the machining of lead and also melted lead in C-720.

4.3 Weapons Component Dismantlement and Metals Recovery

The weapons component processing and metals recovery activities involved the dismantlement of hundreds of damaged or retired nuclear weapons that had been previously partially disassembled at Pantex. The weapons were shipped to Paducah without the explosive and nuclear physics packages. Nuclear weapons training assemblies, that did not contain the explosive and nuclear physics packages, also were shipped directly from military installations.

Although an implied understanding with Pantex (Ref. 2) intended to ship only the non-nuclear (and it was believed, consequently, non-contaminated) portions of retired weapons to Paducah, on occasion, parts that may have been radioactively contaminated were shipped to Paducah. Neutron generators were received at Paducah in 1964 (Ref. 5) and possibly earlier. In addition, the receipt of several inadvertent shipments of radioactive items in late 1981 and early 1982 was discovered in mid-1982 (Ref. nos. 2, 10). These items were returned to Pantex or buried at Paducah in the classified burial yard.

From the data collected, it is clear that radioactive materials were periodically shipped to Paducah. Pantex documents confirmed that some weapons components/parts were sent to Paducah, for material reclamation, disposal, sanitization and demilitarization of the configuration of weapons parts. Even though the 1982 discovery represented a mishandling of material at Pantex, the likelihood that frequent errors occurred is low because Pantex had a procedural control process for dismantling and dispositioning weapons parts. A memorandum (Ref. 10) positively identified two types of radioactive parts that were shipped: 1) Neutron generators and 2) uranium chips. Measurements on boxes in which neutron generators were shipped showed moderate radiation levels (on the order of 60mr/hr on contact). Lower radiation levels were found on two uranium metal parts left in the mid-sections (on the order of 12 mr/hr). The estimates made at the time
demonstrate that even if the same worker had removed material from two hundred of the devices for processing, he would have received an exposure of about 100 mrem to the hands. This was far less than the allowable limit, at that time, 75 rem. It is likely that the cadre of workers at the smelter involved in dismantling weapon components received
some low to moderate radiation exposure during the life of the operations. Identifying actual exposure to any individual would be difficult; however, an upper bound on the dose can be estimated based on the operations conducted.

4.4 Materials Placed in Classified Burial Yard

Several hundred tons of non-usable nuclear weapons component material were buried in the classified burial yard, including possibly two assembled weapons without the explosive and nuclear physics packages. Tritium was received at Paducah as early as 1964. This isotope was contained in neutron generators received at Paducah for disposal by burial or other means. Shipment of the neutron generators occurred for several years. At the time, a review of the hazards associated with the disposal of tritium concluded that the release of tritium near personnel could result in radiation exposure. It was further determined that the tritium content would probably not be released from the reservoirs by rough handling of the generators or removal of the external electrical connectors. The Paducah staff noted that because of the relative short half-life of tritium (12.5 years) the radioactivity would, in about 120 years, decrease to about 0.1% of the level at which it was buried. Thus, it was concluded that there were no unusual hazards in the burial of an undetermined number of neutron generators in the designated area west of the C-746-A warehouse (Ref. 5). (Note that today, in 2000, approximately 3 half-lives have passed and ~13% of the original 1965 radioactivity remains.) The recent Pantex Health Physics characterization data supports the low level hazard of tritium. The review by Paducah also stated that this was based on a provision that certain precautions were taken, such as precautions to not to crush the reservoirs during handling and the control of re-excavation of the burial areas to prevent inadvertent removal of the reservoirs.

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5. "Disposal of Neutron Generators," Internal Memorandum from R. A. Winkel to B. N. Stiller, dated October 13, 1965.

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APPENDIX A: CHRONOLOGY OF PADUCAH WORK FOR OTHERS ACTIVITIES 1958-1988